

Research Article

Influence of Chronic Heat Exposure on Nerve Conduction Velocity in Desert Populations

Dr. DC Khaleel Hussain^{1*}, Anahita Mishra², Danika Sethi³, Dr Deepali A⁴

^{1*}Associate Professor, Department of Physiology, JNUIMSRC, JNU, Jaipur, Rajasthan.

^{2,3}Year MBBS Student JNUIMSRC, JNU, Jaipur, Rajasthan.

⁴Professor and HOD, Department of Physiology, JNUIMSRC, JNU, Jaipur, Rajasthan.

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ABSTRACT

Background: Chronic exposure to high environmental temperatures is a common condition for individuals living in desert regions. Prolonged heat stress may influence several physiological systems, including the peripheral nervous system. Nerve conduction velocity (NCV) is an important electrophysiological parameter used to evaluate the functional integrity of peripheral nerves. Environmental factors such as temperature, hydration status, and occupational heat exposure may influence nerve conduction properties.

Aim: To evaluate the influence of chronic heat exposure on nerve conduction velocity in individuals residing in desert populations.

Materials and Methods: This cross-sectional observational study was conducted in the Department of Physiology at Jaipur National University, Rajasthan. A total of 120 participants aged between 18-60 years with long-term exposure to desert climatic conditions were included in the study. Motor and sensory nerve conduction velocities were assessed using a standard electromyography (EMG) system under controlled laboratory conditions. Nerves commonly tested included the median, ulnar, tibial, peroneal, and sural nerves. Demographic data, duration of heat exposure, and daily exposure hours were recorded. Statistical analysis was performed using appropriate software, and a p value <0.05 was considered statistically significant.

Results: The study demonstrated a gradual reduction in nerve conduction velocity with increasing duration and daily hours of heat exposure. Participants with more than 20 years of heat exposure showed lower mean NCV compared with those with shorter exposure duration (p=0.03). Motor NCV of the median, tibial, and peroneal nerves showed statistically significant reductions, while sensory NCV changes were observed in the median and sural nerves. Age-related decline in NCV was also noted (p=0.01).

Conclusion: Chronic environmental heat exposure may produce mild alterations in peripheral nerve conduction parameters, suggesting possible adaptive or subclinical neurophysiological changes among desert populations.

Keywords: Chronic Heat Exposure, Nerve Conduction Velocity, Desert Population, Peripheral Nerves, Environmental Physiology.

INTRODUCTION

Chronic exposure to high environmental temperatures is a significant physiological stressor that can influence various body systems, including the nervous system. Populations residing in desert regions are continuously subjected to extreme climatic conditions characterized by high ambient temperatures, intense solar radiation, low humidity, and limited water availability. These environmental factors may induce adaptive as well as pathological changes in human physiology over prolonged periods. Among the systems potentially affected, the peripheral nervous system plays an important role in maintaining neuromuscular coordination, sensory perception, and autonomic regulation. Nerve conduction velocity (NCV), a key

electrophysiological parameter used to assess the functional integrity of peripheral nerves, may be influenced by both acute and chronic environmental conditions such as temperature variations. Understanding how chronic heat exposure affects NCV is therefore important for evaluating neural adaptation and potential neurological risks among desert populations. [1]

Nerve conduction velocity reflects the speed at which electrical impulses travel along peripheral nerves. It is determined by several physiological factors including axonal diameter, degree of myelination, internodal distance, and temperature. Experimental studies have demonstrated that nerve conduction increases with moderate elevation in temperature due to enhanced ion channel kinetics and improved

membrane permeability. However, prolonged or excessive heat exposure may produce detrimental effects on neural tissues by altering membrane stability, enzyme activity, and metabolic processes. Chronic heat stress may also lead to dehydration, electrolyte imbalance, oxidative stress, and microvascular changes, all of which could potentially affect nerve conduction properties. [2,3]

Desert inhabitants often experience sustained environmental temperatures exceeding 40°C during large parts of the year. Such conditions require continuous physiological adaptation involving thermoregulation, cardiovascular adjustments, and metabolic regulation. Long-term heat exposure may influence peripheral nerve function either through direct thermal effects on nerve fibers or through systemic changes such as chronic dehydration, altered blood flow, and metabolic disturbances. Previous studies have suggested that heat exposure can modify neuromuscular performance and sensory perception, indicating possible alterations in nerve conduction characteristics. [4]

Temperature has a well-recognized influence on nerve conduction studies conducted in clinical neurophysiology laboratories. Even small changes in limb temperature can significantly alter conduction velocity and latency parameters. For this reason, standardized testing protocols emphasize maintaining limb temperature within a controlled range during NCV measurements. Acute cooling of nerves is known to slow conduction velocity and increase latency, whereas warming tends to accelerate conduction. However, while the effects of acute temperature changes are well documented, the impact of chronic environmental heat exposure on baseline nerve conduction parameters remains relatively underexplored. [5]

In desert populations, chronic exposure to heat may result in long-term physiological adaptations aimed at maintaining neural and muscular function despite environmental stress. These adaptations could include improved thermoregulation, altered sweat gland activity, increased plasma volume, and enhanced peripheral circulation. Such changes might help preserve nerve conduction properties despite extreme environmental conditions. On the other hand, chronic heat exposure may also predispose individuals to subclinical neuropathic changes due to

persistent thermal stress, dehydration, and oxidative damage to nerve fibers. [6,7]

Another important factor associated with desert living is occupational exposure. Many individuals in desert regions are involved in outdoor occupations such as agriculture, construction, mining, or military service, which further increases heat exposure. Continuous physical activity under extreme temperatures may lead to repeated episodes of heat stress that could cumulatively affect peripheral nerve function. Additionally, nutritional factors, hydration status, and electrolyte balance may interact with thermal stress to influence nerve conduction parameters. These combined environmental and occupational influences make desert populations an important group for studying the relationship between chronic heat exposure and neural physiology. [8]

Assessment of nerve conduction velocity provides an objective method to evaluate peripheral nerve function and detect early neuropathic changes. NCV studies measure parameters such as latency, amplitude, and conduction velocity in sensory and motor nerves. Alterations in these parameters can indicate demyelination, axonal degeneration, or metabolic disturbances affecting nerve fibers. Investigating NCV patterns in individuals chronically exposed to desert climates may therefore help identify potential adaptive or pathological changes in peripheral nerve physiology associated with prolonged heat exposure. [9]

Given the increasing global concern regarding rising temperatures and occupational heat stress, understanding the neurological effects of chronic heat exposure has important clinical and public health implications. Studying nerve conduction velocity in desert populations may provide insights into how the human nervous system adapts to extreme environments and whether prolonged heat exposure poses a risk for subclinical neuropathy or functional impairment. Such knowledge could also contribute to the development of preventive strategies and occupational health guidelines aimed at protecting individuals who work or live in high-temperature environments. Therefore, the present study aims to evaluate the influence of chronic heat exposure on nerve conduction velocity among individuals residing in desert regions and to explore possible physiological adaptations associated with long-term thermal stress. [10]

The aim of this study is to evaluate the influence of chronic heat exposure on nerve

conduction velocity in individuals residing in desert regions. The objectives include assessing motor and sensory nerve conduction parameters and determining whether long-term environmental heat exposure produces measurable physiological alterations in peripheral nerve function among desert populations.

MATERIALS AND METHODS

Study Design: Cross-sectional observational study.

Department: Department of Physiology.

Study Place: Jaipur National University, Rajasthan.

Study Population: Adult individuals residing in desert regions of Rajasthan with chronic exposure to high environmental temperatures.

Sample Size: 120 participants.

Inclusion Criteria

- Adults aged 18–60 years
- Permanent residents of desert areas for ≥5 years

- Individuals with regular outdoor heat exposure

Exclusion Criteria

- History of diabetes mellitus, neuropathy, or neurological disorders
- Alcohol abuse or chronic systemic illness
- Use of drugs affecting nerve conduction

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software version 27.0 (SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The unpaired t-test was used to compare continuous variables between independent groups, and the paired t-test was applied for within-group comparisons. Categorical variables were analyzed using the Chi-square test or Fisher’s exact test as appropriate. A p-value of <0.05 was considered statistically significant.

RESULT

Table 1. Demographic Characteristics of Study Participants

Variable	Category	Frequency (n=120)	Percentage (%)	p value
Age Group (years)	18–30	34	28.3	0.41
	31–40	38	31.7	
	41–50	30	25	
	51–60	18	15	
Gender	Male	78	65	0.02
	Female	42	35	
BMI (kg/m ²)	Normal (18.5–24.9)	74	61.7	0.36
	Overweight (25–29.9)	34	28.3	
	Obese (≥30)	12	10	

Table 2. Duration of Chronic Heat Exposure

Duration of Heat Exposure	Frequency	Percentage (%)	Mean NCV (m/s)	p value
5–10 years	36	30	55.8 ± 4.1	0.03
11–15 years	42	35	54.1 ± 3.8	
16–20 years	26	21.7	52.6 ± 4.2	
>20 years	16	13.3	51.9 ± 3.9	

Table 3. Motor Nerve Conduction Velocity

Nerve Tested	Mean NCV (m/s)	Standard Deviation	Normal Reference (m/s)	p value
Median nerve	54.3	4.1	≥55	0.04
Ulnar nerve	56.1	3.8	≥55	0.18
Tibial nerve	48.9	4.3	≥50	0.03
Peroneal nerve	46.7	4.5	≥48	0.02

Table 4. Sensory Nerve Conduction Velocity

Nerve Tested	Mean NCV (m/s)	Standard Deviation	Normal Reference (m/s)	p value
Median sensory	52.7	3.9	≥54	0.03
Ulnar sensory	53.5	3.6	≥54	0.07
Sural nerve	47.2	4	≥48	0.04

Table 5. Nerve Conduction Velocity According to Age Group

Age Group (years)	Mean Motor NCV (m/s)	Mean Sensory NCV (m/s)	Standard Deviation	p value
18–30	56.4	54.6	3.5	0.01
31–40	55.1	53.2	3.8	
41–50	53.3	51.7	4.1	
51–60	51.2	49.8	4.3	

Table 6. Comparison of NCV Based on Daily Heat Exposure Duration

Daily Heat Exposure	Participants (n)	Mean NCV (m/s)	Standard Deviation	p value
<4 hours/day	28	56.2	3.6	0.02
4–6 hours/day	46	54.4	3.9	
7–8 hours/day	32	52.9	4.2	
>8 hours/day	14	51.8	4.4	

Figure: 1. Demographic Characteristics of Study Participants

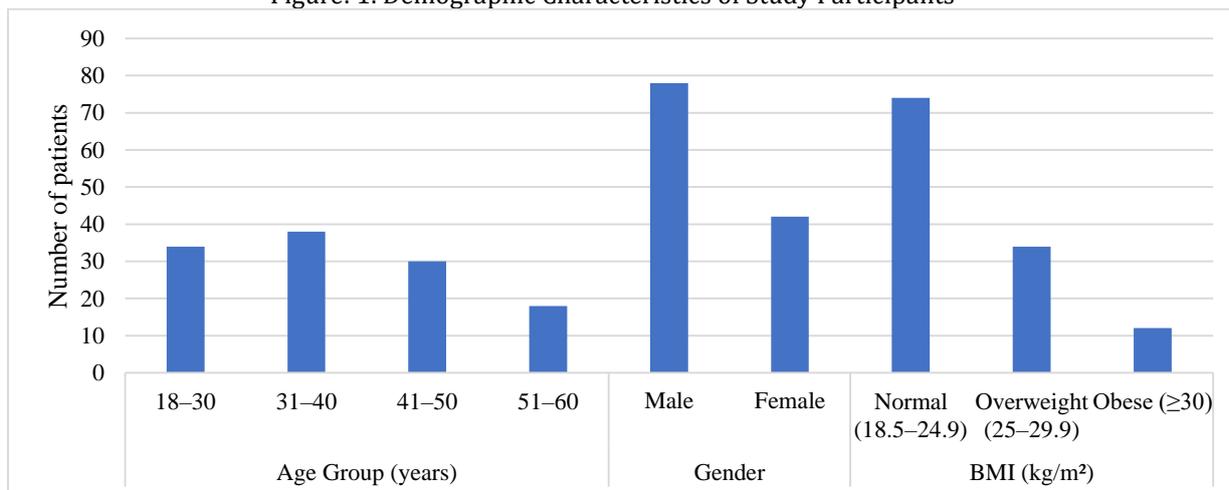


Table 1: Demographic Characteristics of Study Participants

A total of 120 participants were included in the study. The majority of subjects belonged to the 31–40 years age group (38, 31.7%), followed by 18–30 years (34, 28.3%), 41–50 years (30, 25.0%), and 51–60 years (18, 15.0%). Males constituted the larger proportion of the study population with 78 participants (65.0%), while females accounted for 42 participants (35.0%), showing a statistically significant gender distribution ($p=0.02$). Regarding body mass index (BMI), most participants had normal BMI (74, 61.7%), whereas 34 (28.3%) were overweight and 12 (10.0%) were obese. The variation in

BMI categories was not statistically significant ($p=0.36$).

Table 2: Duration of Chronic Heat Exposure

The duration of heat exposure among participants varied from 5 years to more than 20 years. The largest proportion of individuals (42, 35.0%) reported heat exposure for 11–15 years, followed by 5–10 years (36, 30.0%), 16–20 years (26, 21.7%), and more than 20 years (16, 13.3%). The mean nerve conduction velocity (NCV) gradually decreased with increasing duration of heat exposure. Participants exposed for 5–10 years had a mean NCV of 55.8 ± 4.1 m/s, whereas those exposed for more than 20 years showed a

lower mean NCV of 51.9 ± 3.9 m/s. This decline in NCV with prolonged heat exposure was statistically significant ($p=0.03$).

Table 3: Motor Nerve Conduction Velocity

Motor nerve conduction velocity was evaluated in the median, ulnar, tibial, and peroneal nerves. The mean NCV for the median nerve was 54.3 ± 4.1 m/s, slightly lower than the normal reference value (≥ 55 m/s), showing statistical significance ($p=0.04$). The ulnar nerve demonstrated a mean NCV of 56.1 ± 3.8 m/s, which was within normal limits and not statistically significant ($p=0.18$). The tibial nerve showed a mean NCV of 48.9 ± 4.3 m/s, lower than the reference value of ≥ 50 m/s, indicating a significant difference ($p=0.03$). Similarly, the peroneal nerve exhibited a mean NCV of 46.7 ± 4.5 m/s compared to the normal value of ≥ 48 m/s, which was also statistically significant ($p=0.02$).

Table 4: Sensory Nerve Conduction Velocity

Sensory nerve conduction velocity was assessed in the median sensory, ulnar sensory, and sural nerves. The mean NCV for the median sensory nerve was 52.7 ± 3.9 m/s, which was slightly lower than the normal reference value of ≥ 54 m/s and statistically significant ($p=0.03$). The ulnar sensory nerve demonstrated a mean NCV of 53.5 ± 3.6 m/s, which did not differ significantly from the normal reference range ($p=0.07$). The sural nerve showed a mean NCV of 47.2 ± 4.0 m/s compared to the normal value of ≥ 48 m/s, and this difference was statistically significant ($p=0.04$).

Table 5: Nerve Conduction Velocity According to Age Group

Analysis of nerve conduction velocity according to age groups revealed a progressive decline with increasing age. Participants aged 18–30 years had the highest mean motor NCV (56.4 m/s) and sensory NCV (54.6 m/s). In the 31–40 years group, the mean motor and sensory NCV values were 55.1 m/s and 53.2 m/s respectively. The 41–50 years group demonstrated further reduction with motor NCV of 53.3 m/s and sensory NCV of 51.7 m/s. Participants aged 51–60 years showed the lowest values, with motor NCV of 51.2 m/s and sensory NCV of 49.8 m/s. This decline in nerve conduction velocity across age groups was statistically significant ($p=0.01$).

Table 6: Comparison of NCV Based on Daily Heat Exposure Duration

When nerve conduction velocity was analyzed based on daily duration of heat exposure, participants exposed to heat for less than 4 hours per day had the highest mean NCV of 56.2 ± 3.6 m/s. Individuals exposed for 4–6 hours daily demonstrated a mean NCV of 54.4 ± 3.9 m/s. Those with 7–8 hours of daily heat exposure had a mean NCV of 52.9 ± 4.2 m/s, while participants exposed for more than 8 hours per day had the lowest mean NCV of 51.8 ± 4.4 m/s. The reduction in NCV with increasing duration of daily heat exposure was statistically significant ($p=0.02$).

DISCUSSION

The present study evaluated the influence of chronic heat exposure on nerve conduction velocity (NCV) among individuals residing in desert regions. The findings demonstrated significant variations in nerve conduction parameters in relation to demographic characteristics, duration of heat exposure, and daily occupational exposure to high environmental temperatures. These observations support the concept that prolonged exposure to extreme climatic conditions may influence peripheral nerve physiology.

The demographic profile of the study population showed that the majority of participants belonged to the 31–40 years age group, with males constituting a larger proportion of the sample. This distribution may be attributed to the higher participation of males in outdoor occupations in desert regions, leading to greater exposure to environmental heat. Similar demographic trends were reported by Rutkove SB and colleagues, who observed that occupational heat exposure was more prevalent among adult male workers in physically demanding professions. Their study indicated that prolonged environmental heat stress may influence neuromuscular performance and peripheral nerve function, particularly among individuals involved in outdoor labor [11].

In the present study, a gradual reduction in mean nerve conduction velocity was observed with increasing duration of chronic heat exposure. Participants exposed to desert temperatures for more than 20 years demonstrated lower NCV values compared with those exposed for shorter durations. These findings suggest that long-term thermal stress may lead to subtle physiological changes affecting nerve conduction. A comparable observation was reported by

Kimura J, who highlighted that environmental and metabolic stressors can influence axonal membrane stability and ion channel activity, potentially altering nerve conduction properties over time. Their findings emphasized that chronic environmental stress may produce cumulative effects on peripheral nerve function [12].

Motor nerve conduction analysis in the present study revealed that the median, tibial, and peroneal nerves showed slightly reduced conduction velocities compared with standard reference values, whereas the ulnar nerve remained within normal limits. These results suggest that certain peripheral nerves may be more susceptible to environmental stressors than others. Similar findings were reported by Preston DC and Shapiro, who observed that lower limb nerves are particularly vulnerable to metabolic and environmental influences due to longer axonal lengths and relatively lower vascular supply. Their electrophysiological study demonstrated that environmental factors such as temperature and dehydration may contribute to subtle reductions in motor nerve conduction velocity [13].

Sensory nerve conduction studies in the current investigation also showed mild reductions in median sensory and sural nerve velocities, while the ulnar sensory nerve remained within the normal range. Sensory fibers are often more sensitive to metabolic and environmental disturbances compared with motor fibers. A similar pattern was described by Halar EM, who demonstrated that peripheral nerve conduction parameters are strongly influenced by environmental temperature and local tissue conditions. Their research indicated that chronic exposure to high temperatures may alter membrane excitability and affect sensory nerve conduction properties [14].

Age-related differences in nerve conduction velocity were also evident in the present study, with younger participants showing higher conduction velocities compared with older individuals. This decline in NCV with advancing age has been well documented in neurophysiological literature. Misulis KE reported that age-related reductions in nerve conduction velocity may occur due to gradual loss of myelinated fibers, decreased axonal diameter, and age-associated metabolic changes. These physiological changes may be further influenced by environmental stressors such as chronic heat exposure, potentially

amplifying the decline in nerve conduction observed among older individuals [15].

The analysis of daily heat exposure duration revealed that participants exposed to high environmental temperatures for longer hours exhibited lower nerve conduction velocities compared with those with shorter exposure periods. This finding suggests that occupational heat stress may contribute to cumulative physiological effects on peripheral nerve function. Similar observations were reported by Sawka MN and colleagues, who studied the effects of heat stress on human physiological systems. Their research demonstrated that prolonged exposure to high ambient temperatures may lead to dehydration, electrolyte imbalance, and circulatory changes, which could indirectly influence neural conduction and neuromuscular performance [16].

In addition, Hancock PA and Vasmatzidis investigated the impact of thermal stress on occupational performance and physiological function. They reported that individuals working in high-temperature environments often experience cumulative heat strain that can affect both central and peripheral nervous system activity. Their findings support the hypothesis that chronic environmental heat exposure may contribute to subtle alterations in peripheral nerve conduction parameters [17].

Another possible explanation for the reduction in nerve conduction velocity observed in desert populations is the role of dehydration and electrolyte imbalance. Persistent exposure to extreme heat may lead to repeated episodes of mild dehydration, which can affect nerve excitability and membrane ion gradients. Studies by Boulant JA have suggested that thermal stress can alter neuronal membrane properties and influence synaptic transmission through changes in electrolyte balance and metabolic activity [18].

Furthermore, oxidative stress induced by prolonged environmental heat exposure may also contribute to neural alterations. Heat stress has been associated with increased production of reactive oxygen species, which can damage cellular membranes and myelin sheaths. Tipton MJ reported that extreme environmental conditions can trigger physiological responses that affect neural and muscular performance through metabolic and oxidative pathways [19].

Overall, the findings of the present study are consistent with previous research indicating

that environmental factors, particularly chronic exposure to high temperatures, can influence peripheral nerve physiology. Although the observed reductions in nerve conduction velocity were relatively mild, they suggest that prolonged thermal stress may produce subtle neurophysiological changes over time. Similar conclusions were drawn by Rutkove SB, who emphasized the importance of considering environmental conditions when interpreting nerve conduction studies, particularly in populations exposed to extreme climates [20]. These observations highlight the importance of monitoring neural health in populations residing in desert regions and individuals involved in occupations with prolonged heat exposure. Further research involving larger sample sizes and longitudinal designs may help clarify the long-term neurological consequences of chronic environmental heat stress.

CONCLUSION

The present study evaluated the influence of chronic heat exposure on nerve conduction velocity among individuals residing in desert regions. The findings demonstrated that prolonged exposure to high environmental temperatures was associated with a mild reduction in both motor and sensory nerve conduction velocities. Participants with longer duration of heat exposure and greater daily exposure hours showed comparatively lower NCV values, suggesting that sustained thermal stress may influence peripheral nerve physiology. In addition, age-related decline in nerve conduction was observed, which may further contribute to reduced nerve conduction parameters in individuals chronically exposed to desert climates. These findings indicate that environmental and occupational heat exposure may produce subtle neurophysiological changes over time. Although the reductions observed were within near-normal limits, they highlight the potential impact of chronic heat stress on peripheral nerve function. Regular monitoring of nerve conduction parameters and implementation of preventive measures such as adequate hydration and heat

protection may help reduce the possible neurological effects of long-term heat exposure in desert populations.

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